Bidding for Firms with Unknown Characteristics*

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Abstract

When a region successfully attracts a firm by offering tax concessions, outright subsidies etc., the firm often commits itself to performance targets in terms of investment or employment. This paper interprets these firm-specific targets as a consequence of incomplete information. It analyzes a model of two regions which compete for a firm assuming that the firm's characteristics are ex-ante unknown. We consider direct mechanisms that induce truthful reporting of the firm's type. We find that, first, firm-specific performance targets are an equilibrium outcome if information is incomplete. Second, these performance targets often induce overemployment. Third, under incomplete information, low regional tax rates, wage rates, or unemployment benefits are a competitive advantage (which is not the case under complete information). Fourth, this competitive advantage not only implies that the more attractive region wins the bidding competition but also that this region may gain from the fact that information is incomplete, i.e. its payoff is greater than it would be under complete information.

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1 Introduction

The location of a firm in a given jurisdiction can substantially increase its residents' welfare – by increasing employment, wages and tax revenue. It is therefore not surprising that municipal or regional governments are willing to offer tax concessions or outright subsidies to attract firms. Often these financial incentives are associated with some specific performance commitment in terms of investment, output or – in most cases – employment. These firm-specific commitments may be interpreted as a consequence of incomplete information: An individual region is willing to bid for the firm according to the surplus it creates – but the size of the surplus may a priori be unknown or, at least, only imprecisely measurable. By committing itself to some performance target, the firm may signal its type and, thus, reduce the information asymmetry.

In this paper, we consider a model with two regions which engage in a bidding competition for a firm with unknown characteristics. These characteristics will ultimately determine the welfare gain from attracting the firm. Welfare gains take the form of increased tax revenue and reduced unemployment. We consider direct non-linear mechanisms that induce truthful reporting of the firm's type under both symmetric and asymmetric competition.

We find that, first, as with complete information, the symmetric equilibrium under incomplete information generally yields zero expected regional payoffs and full capture of the surplus by each type of firm. Second, equilibrium offers to the firm are conditioned on specific employment levels (individual performance targets). Third, equilibrium offers may induce employment distortions. Fourth, in asymmetric settings (i.e. where regions differ in tax rates, wages or unemployment benefits), situations may arise where regional payoffs are larger than in the case of complete information. This might be surprising, since the regions are the uninformed parties in this game. Finally, if regions differ in tax rates, the low-tax region will win the bid, which is not the case under complete information. The reason is that low taxes allow for less distortive equilibrium offers. Similar results arise if

regions differ in wages or unemployment benefits.

In the literature on regional competition for the location of firms,[4] an important question is why the region wants to attract a firm. In this paper, our answer to this question is tax revenue and jobs, like e.g. in Boadway et al. (2002). However, we neglect spillovers (Olsen and Osmundsen 2003), the impact of firm location on competition (Haufler and Wooton 1999), consumer surplus (Becker and Fuest 2010), and agglomeration economies (Baldwin and Okubo 2009). We also abstract from any considerations of industry structure.[5]

The focus of this paper is on the role of incomplete information which has been considered by a number of predecessor studies. Bond and Samuelson (1986) assume that the region has more information on the location quality than the firm. Tax holidays may then act as a signal for good location quality. Private information on the side of the bidding governments is also considered in Furusawa et al. (2015).[6] King et al. (1993) study the role of incomplete information when firms may relocate and, thus, have an incentive to update their expectations of location-specific profits. Black and Hoyt (1989) briefly consider the case in which the firm has private information on the cost differences between regions. If cost parameters are different across regions, part of the surplus is region specific. This perspective is taken in Scoones and Wen (2001) who show that the degree of bidding competition decreases in the share of region specific surplus. Konrad and Lommerud (2001) show that, if the firm has private information, this may alleviate the hold-up problem with foreign investment since the firm keeps some information rent.

When the set of policy instruments to attract the firm becomes more sophisticated, a region may use direct mechanisms that induce truth-telling

[4]The tax sensitivity of firm location has been examined in a wide variety of studies which are surveyed by Devereux (2007), Zodrow (2010) and Feld and Heckemeyer (2011).

[5]There is a literature strand of its own dealing with the analysis of heterogeneous firms in the tradition of Melitz (2003) and Helpman et al. (2004). Chor (2009), Davies and Eckel (2010), Becker and Fuest (2011) as well as Haufler and Stähler (2013) analyze optimal tax policy in the presence of heterogeneous mobile firms.

[6]A simple setting with two-sided private information is analyzed in King and Welling (1992).

about actual profits and employment levels, building on Baron and Myerson (1982). There are two general approaches to model regional competition for firms under incomplete information. The common agency approach (see, e.g., Martimort and Stole 2002, for a general treatment) assumes that two principals (i.e. two regions) simultaneously provide incentives for one agent (i.e. one firm). That is, the firm is located in two regions and is simultaneously affected by the policy choices in these regions. For instance, Olsen and Osmundsen (2001, 2003) adopt a two-region model from Haaparanta (1996) where the firm invests in both regions due to the concavity of local production functions. They analyze tax competition for capital allocated within the firm when the firm has private information on its productivity. The screening equilibrium implies a downward distortion of investment.[7] In this paper, we take the alternative approach which has two principals compete for the exclusive service of an agent, see e.g. Biglaiser and Mezzetti (1993, 2000).[8] That is, there is regional competition for the *exclusive* location of a firm.[9] To the best of our knowledge, we are the first to apply this framework to the context of regional competition for firms. In line with the theory, we find that a direct truth-inducing mechanism implies overemployment instead of underemployment (the latter of which corresponds to the underinvestment result of Olsen and Osmundsen 2001, 2003). The specific context of regional bidding competition for firms yields a number of results

[7] Osmundsen et al. (1998) finds a similar result (downward distortion of investment) for a small country facing a passive world market.

[8] See also Bierbrauer et al. (2013) who analyze non-linear taxation of individuals with perfect labor mobility. In their framework, two competing governments implement direct mechanisms to let individual agents reveal their type. They find that, in most cases, redistribution (i.e. taxes and subsidies) do not survive perfect labor mobility – the equivalent finding in our paper is that firms receive the full surplus (at least in the symmetric setting).

[9] A crucial difference between these two approaches is that, e.g. in the common agency approach, e.g. Olsen and Osmundsen (2001, 2003), a region effectively competes for the marginal unit of capital, which often has a net social return of zero. In contrast, assuming that the firm either locates in this or the other region implies that all tax revenue, all employment and all spillovers is concentrated in the region that wins the bidding competition. This gives rise to Bertrand-style competition and a race to the bottom. If however, part of the firm always remains in one country, tax rates will never reach the bottom (due to the trade-off between taxing intramarginal units and competing for marginal units).

beyond those derived from an application of the model by Biglaiser and Mezzetti (1993, 2000). For instance, we show that the tightness of the incentive compatibility constraints depends on the level of regional tax rates; as a consequence, the low-tax region wins the bidding competition if anything else is equal (which is not the case under complete information). In addition, we demonstrate that, with asymmetries in tax rates, wages, or unemployment benefits, the winning region actually benefits from incomplete information.

From an empirical point of view, there is large and extensive evidence of firm-specific state aids, subsidies or tax holidays, see e.g. Besley and Seabright (1999). Policies to attract foreign firms are anything but homogeneous. In some cases, unconditional tax credits seem to be the main policy instrument. For instance, in 2010, Michigan won over Ohio by attracting a new Chrysler assembly plant offering the firm a $1.3 billion state tax credit over 20 years.[10] More recently, the rental car service Hertz announced to move its headquarters to Florida in exchange of $16.8 million of immediate payments and tax credits worth $68 million over 20 years.[11] In other cases, tax rebates are associated with an incentive to employ domestic workers, as it was the case with Thyssen Krupp in 2007 (and later in 2011) investing in Mobile County (Alabama).[12] Moreover, governments sometimes fix specific investment and employment targets. For example, Boeing will only receive the full subsidy package with a total value of $900 million (offered to it in 2009 to build a new aircraft plant in North Charleston) if some specific investment and jobs targets are met.[13] Another example is the case

[10]See Michigan Economic Development Corporation (October 26, 2010). Available at http://www.michiganbusiness.org/press-releases/governor-granholm-announces-historic-investment-in-michigan/.

[11]See Lynn K., Hugh, R.M. and L. Moss (May 7, 2013). Hertz moving 550 from Park Ridge HQ to Florida. NorthJersey.com. Available at: http://www.northjersey.com/parkridge/206408211_Hertz_moves_from_New_Jersey_to_Florida.html.

[12]See Jeff Amy (April 28, 2011). Alabama state and local aid to ThyssenKrupp tops $1 billion after vote. Mobile Register. Available at http://blog.al.com/live/2011/04/alabama_state_and_local_aid_to.html.

[13]Data are taken from David Slade (January 17, 2010): Boeing's whopping incentives. The Post and Courier. Available at

of Nokia, from which the State of Northrhine-Westfalia successfully claimed back 40 million € arguing that the firm did not meet the employment targets.[14] In this paper, we rationalize this kind of contract and, with some interpretation, even the incentive to employ less people than contractually fixed.

The remainder of the paper is organized as follows. The next section introduces the model setup. Section 3 outlays the benchmark with complete information. Section 4 analyzes the bidding competition under symmetry assumptions. Section 5 examines different assumptions about asymmetry between the two competing regions. Section 6 discusses the results and concludes.

2 Model setup

Consider a world with two regions, $i = 1, 2$ (the index will be suppressed until misunderstanding arises) which compete for the location of a firm.

2.1 The region

In each region, there is a large number of households, normalized to unity. Households are either employed or unemployed. Employed households supply one unit of labor and receive labor income of w. Unemployed households receive benefits of w^s from the government. Household k's utility function is given by

$$u\left(c_k, I_k, g\right) = v\left(c_k, I_k\right) + g \tag{1}$$

where $c_k \in \{w, w^s\}$ is consumption, I_k is a binary variable that equals one if the household works and zero if not, and g is a public good. We assume $\partial v(c_k)/\partial c_k > 0 > \partial^2 v(c_k)/\partial c_k^2$ that is the households' utility increases in consumption with a decreasing rate. Moreover, we assume $v(c_k, 1) < v(c_k, 0)$ that is there is a disutility of work. The household chooses between being

http://www.postandcourier.com/article/20100117/PC1602/301179958.

[14] See Louven S. and Slodczyk K. (March 11, 2008). Available at http://www.handelsblatt.com/politik/deutschland/subventionszahlungen-nrw-will-60-millionen-von-nokia-seite-all/2932968-all.html

employed and unemployed whichever maximizes her utility. This implies a labor supply function which depends on w and w^s.

Moreover, in each region, there is a large number of identical small firms, normalized to unity. The representative firm has a production technology $f(n)$, with $\partial f(n)/\partial n > 0 > \partial^2 f(n)/\partial n^2$, where $n \in [0,1)$ denotes the production input labor. Pre-tax profits are given by

$$f(n) - wn. \tag{2}$$

Profit maximizing implies $\partial f(n)/\partial n = w$ and thus a labor demand function $n(w)$ with $\partial n(w)/\partial w < 0$.

The region's government is assumed to be benevolent and to maximize the households' utility. It generates tax revenue due to the taxation of firm profits and pays unemployment benefits w^s. Both the profit tax rate t and the unemployment benefit w^s are determined by some supra-regional entity, i.e. apart from bidding for the firm, the regional government is completely passive. The labor market equilibrium is thus characterized by a wage rate and labor demand satisfying

$$v(w,1) = v(w^s,0) \quad \text{and} \quad \frac{\partial f(n)}{\partial n} = w, \tag{3}$$

respectively. By (3) utility levels of the employed and unemployed are equal. Beside levying taxes on firm profits and paying unemployment benefits the government provides regional public goods g (with tax revenue being transformed into the public good on a one-to-one basis). Since households' utility generated due to the consumption of a private good, i.e. $v(c_k, I_k)$, is not affected by the government, the government maximizes the households' utility by maximizing the level of public goods. The government's objective is given by

$$\begin{aligned} &\max g \\ &\text{s.t. } t(f(n) - wn) \geq w^s(1-n). \end{aligned} \tag{4}$$

The level of public goods that is provided without the attraction of the firm therefore is

$$g = t\left(f\left(n\right) - wn\right) - w^s(1-n). \tag{5}$$

2.2 The firm

The firm locates in either of the two regions. It chooses the location which offers the largest net payoffs (including tax breaks, subsidies, upfront payments etc.). If payoffs are equal in both regions, the firm is indifferent between both locations and chooses each region with equal probability. Once the firm has chosen the location, it stays there.[15]

The firm is characterized by a parameter $\theta \in \{l, h\}$, which represents low (l) and high (h) productivity and is private information of the firm (and cannot be credibly revealed). The ex-ante probabilities for the firm characteristic are p_l for the low-productivity type and $p_h \equiv 1 - p_l$ for the high-productivity type. These probabilities are common knowledge. The firm employs labor, N, as the only input good. We assume that $N \in (0, 1-n)$ is sufficiently small to not entirely abolish unemployment; as a consequence, the wage rate will remain stable.

The firm's (pre-tax) profits, Π, are given by

$$\Pi(N;\theta) = F_\theta\left(N\right) - wN, \quad \theta = l, h \tag{6}$$

where $F_\theta(N) \equiv F(N;\theta)$ is a type-dependent production function.

Profit maximization requires $\partial F_\theta(N)/\partial N = w$. We will assume that, at each employment level, the marginal labor productivity is higher for the firm of type h than for the firm of type l, i.e. $\partial F_h(N)/\partial N > \partial F_l(N)/\partial N$ for all N. This implies that (pre-tax) profit maximizing employment is strictly higher in the firm of type h than in the firm of type l and that the firm of type h has weakly larger maximum profits.

The regional government enters a bidding competition for the firm. Like most studies before (see e.g. Boadway et al. 2002, Olsen and Osmundsen

[15] There is no relocation option like in King et al. (1993).

2003), we assume that the region cannot commit on payments long after the investment has taken place. This implies that it cannot condition its bid on realized future profits. However, it can condition its bid on realized employment since this is immediately observable and verifiable (in a court-proof sense).

Definition 1. *A bid is a menue of* $\left(\hat{T}_\theta, \hat{N}_\theta\right)$ *tuples where* $\hat{T}_\theta$ *is a lump-sum payment and* $\hat{N}_\theta$ *is an employment level, both designed for the firm of type* θ*.*

Thus, since there are two types of firms, the bid will typically comprise a menu of two tuples, $\left(\hat{T}_l, \hat{N}_l\right)$ and $\left(\hat{T}_h, \hat{N}_h\right)$.

The timing of the model is as follows: First, both regions simultaneously submit their bids for the firm, that is, a menu of $\left(\hat{T}_{\theta i}, \hat{N}_{\theta i}\right)$ with $i = 1, 2$. Second, the firm chooses a tuple $\left(\hat{T}_{\theta i}, \hat{N}_{\theta i}\right)$ and thereby decides to locate in region i. In addition, the firm chooses its labor demand. Finally, the firm's profits are realized, wages are paid, the government collects revenues, pays unemployment benefits and provides public goods.

3 Benchmark: Bidding competition under complete information

If the firm of type θ accepts the offer and locates in the region, the maximum level of public goods, g_θ, the region's government can provide is determined by a balanced budget which gives

$$g_\theta = t\left(f(n) - wn + F_\theta\left(\hat{N}_\theta\right) - w\hat{N}_\theta\right) - w^s(1-n-\hat{N}_\theta) - \hat{T}_\theta \quad \theta = l, h. \tag{7}$$

The location of the firm increases tax revenue and decreases unemployment benefit payments. It does not increase the wage rate, though. Thus, the household is only affected by the firm via a change in the provision of public goods g. The maximum bid is implied by the level of public goods provision in the absence of the firm, i.e. g.

The region's optimization problem can thus be expressed as follows. The region chooses an offer $\left(\hat{T}_\theta, \hat{N}_\theta\right)$ that maximizes public goods provision; this

may imply, though, that the offer is insufficient to attract the firm, since the region is only willing to bid until $g_\theta = g$, i.e. until the bid makes the household indifferent between attracting the firm and not. Note that, observing the type of the firm, the government offers the firm only the contract designed for it.

Lemma 1. *In the symmetric equilibrium under complete information, the equilibrium bid for the firm of type θ, that is (T_θ^*, N_θ^*), is*

$$T_\theta^* = t\left(F_\theta\left(N_\theta^*\right) - wN_\theta^*\right) + w^s N_\theta^*, \quad \theta = l, h \tag{8}$$

with N_θ^* solving

$$\partial F_\theta(\hat{N}_\theta)/\partial \hat{N}_\theta = w - w^s, \quad \theta = l, h. \tag{9}$$

Proof: There cannot be a symmetric equilibrium where a region offers less than $T_\theta^{\max}$, given by

$$T_\theta^{\max} \equiv t\left(F_\theta(\hat{N}_\theta) - w\hat{N}_\theta\right) + w^s \hat{N}_\theta, \quad \theta = l, h \tag{10}$$

because otherwise the other region has an incentive to increase the bid by a small amount to attract the firm with certainty. A lump-sum payment larger than $T_\theta^{\max}$ cannot be part of an equilibrium because then the attraction of the firm implies a negative net benefit for the region. Given $T_\theta^{\max}$, the firm's surplus is given by $F_\theta\left(\hat{N}_\theta\right) - w\hat{N}_\theta + w^s\hat{N}_\theta$. An employment level of N_θ^* maximizes this surplus. □

The employment level implied by the equilibrium bid, N_θ^*, is larger than the level that the firm would choose in the absence of contractual incentives. The reason is that an additional unit of employment saves the region expenditures on unemployment benefits. However, the type of employment adjustment is not firm-specific (which it will be under incomplete information); a uniform wage subsidy of w^s per unit of employment and a corresponding adjustment of the lump-sum payment may implement the optimal contract. Thus, while equilibrium contracts under complete information

include employment incentives, they are not firm-specific.

4 Incomplete information: symmetric bidding competition

In this section, we consider regional competition for a firm between two symmetric regions when the type of the firm is unknown to the government. Then, the offers have to satisfy incentive compatibility constraints (ICC). Truthful revelation of the firm's type requires that the firm of type h has no incentive to mimic the firm of type l and vice versa. These requirements are summarized in the two following incentive compatibility constraints (ICC_h) and (ICC_l):

$$(1-t)\left(F_h(\hat{N}_h) - w\hat{N}_h\right) + \hat{T}_h \geq (1-t)\left(F_h(\hat{N}_l) - w\hat{N}_l\right) + \hat{T}_l \qquad (ICC_h)$$

$$(1-t)\left(F_l(\hat{N}_l) - w\hat{N}_l\right) + \hat{T}_l \geq (1-t)\left(F_l(\hat{N}_h) - w\hat{N}_h\right) + \hat{T}_h \qquad (ICC_l)$$

The region's optimization problem can now be expressed as follows. The region provides an offer menu, i.e. an offer $\left(\hat{T}_\theta, \hat{N}_\theta\right)$ for each type θ, which satisfies both incentive compatibility constraints (ICC_h) and (ICC_l). It chooses $\left(\hat{T}_l, \hat{N}_l\right)$ and $\left(\hat{T}_h, \hat{N}_h\right)$ such that public goods provision is maximized; again, this may imply that the offer is insufficient to attract the firm, since the region is only willing to bid until the expected public goods provision in the presence of the firm equals the public goods provision in its absence, $p_l g_l + (1-p_l)\, g_h = g$.

Lemma 2. *In any symmetric equilibrium the regions' net benefit from attracting the firm is zero, and each type of the firm gets its full surplus.*

Proof: Suppose that a region has a positive expected net benefit. Then, the other region may increase the lump-sum payments for both types of the firm by a small amount and will therefore attract both types of the firm – and, due to symmetry, will still have a positive net benefit. Thus, in any symmetric equilibrium, the regions' expected net benefit is zero. If, for one type of the firm, the net benefit is positive (and, consequently, for the other

type negative), a region can increase its expected payoffs by offering only the contract that yields a positive net benefit. As a consequence, the net benefit is zero for each type of the firm individually which implies that each type of the firm gets its full surplus. □

Lemma 3. *There is no pooling equilibrium.*

Proof: First note that the best pooling offer, a region can make, is a fixed type-independent lump-sum payment combined with free choice between N_l^* and N_h^* (the pooling property becomes more obvious when a lump-sum payment with a subsidy w^s, both type-independent, are considered). Especially any pooling offer that fixes the employment level for both types of the firm, distorts employment for at least one type of the firm and, thus, reduces the surplus to be distributed. Since with this contract, the firm of type h cross-subsidizes the firm of type l, a region can always deviate by only offering contract specified for the firm of type h with a slightly increased lump-sum payment. If the increase is sufficiently small, the government has a net benefit from attracting the firm of type h. A pooling contract can therefore not be an equilibrium. □

Lemma 4. *In any symmetric separating equilibrium with offers given by* $\left(T_\theta^{\max}\left(\hat{N}_\theta\right), \hat{N}_\theta\right)$, $\theta = l, h$, *(i) employment is given by* $\hat{N}_l \leq N_l^*$ *and* $\hat{N}_h \geq N_h^*$*; (ii) the equilibrium offer made to the firm of type* l *is* $(T_l^{\max}(N_l^*), N_l^*)$.

Proof: With Lemma 2 both governments offer the maximum bid given by (10). (i) With $\hat{T}_\theta = T_\theta^{\max}\left(\hat{N}_\theta\right)$, at most one of the ICCs holds with equality. It follows that at least one of the employment levels is chosen at its desired level, i.e. either $\hat{N}_l = N_l^*$ or $\hat{N}_h = N_h^*$ or both. Now, suppose that $\hat{N}_h = N_h^*$ and $\hat{N}_l > N_l^*$. Then, $\hat{N}_l$ could be reduced and thus increases the firm's surplus (or the region's if the lump-sum payment is reduced) and the ICC_h is relaxed. A similar argument can be made for $\hat{N}_l = N_l^*$ and $\hat{N}_h < N_h^*$. It follows that, in equilibrium, $\hat{N}_l \leq N_l^*$ and $\hat{N}_h \geq N_h^*$. (ii) Since, at $\hat{N}_l \leq N_l^*$ and $\hat{N}_h = N_h^*$, the ICC_h is not binding, it follows that, in equilibrium, the binding constraint is, if at all, the ICC_l. It follows that the offer made to the firm of type l is given by $(T_l^{\max}(N_l^*), N_l^*)$. □

We can now summarize the equilibrium's properties in the following proposition.

Proposition 1. *In the symmetric equilibrium under incomplete information, equilibrium offers are:*

(i) for the firm of type l: $(T_l^{\max}(N_l^*), N_l^*)$*;*

(ii) for the firm of type h: $(T_h^{\max}(N_h^*), N_h^*)$ *if tax rates are sufficiently low and* $\left(T_h^{\max}\left(\hat{N}_h\right), \hat{N}_h\right)$ *with* $\hat{N}_h > N_h^*$ *otherwise.*

Proof: For part (i) see the proof of Lemma 4. For part (ii), consider offers $(T_l^{\max}(N_l^*), N_l^*)$ and $(T_h^{\max}(N_h^*), N_h^*)$. Then the ICC_h holds, see proof of Lemma 4. The ICC_l can be expressed as follows

$$F_l(N_l^*) - (w - w^s) N_l^* - [F_l(N_h^*) - (w - w^s) N_h^*] \geq t (F_h(N_h^*) - F_l(N_h^*)). \tag{11}$$

Thus, if t is sufficiently small, both ICCs hold in equilibrium. If not, a marginal increase in $\hat{N}_h$ at $\hat{N}_h = N_h^*$ relaxes the ICC_l without reducing the profit of the firm of type h. Distorting employment thus enables the government to increase its payment to the high-productivity firm. The government increases the employment target of the firm of type h until the ICC_l holds. □

Part (ii) of Proposition 1 reflects the results derived by Biglaiser and Mezzetti (1993) in the specific setting of a bidding competition for firms. It implies that contractual employment for the firm of type h may be distorted upwards, i.e. there is overemployment. The tightness of the ICC_l depends on the regional level of tax rate.

Proposition 1 characterizes a symmetric separating equilibrium for different environments – in case that it exists. There may be, however, situations in which an equilibrium in pure strategies does not exist, like in the insurance markets model by Rothschild and Stiglitz (1976). To see this, consider a situation in which both types are offered a contract which makes them

capture the full surplus. However, due to distorted labor demand, a deviation is feasible that offers the distorted type a more efficient labor demand while making sure (by reducing $\hat{T}_\theta$) that the ICC of the non-distorted firm type holds with equality. Proposition 2 defines conditions for the existence of a symmetric separating equilibrium.

Proposition 2. *(i) If the equilibrium offers are* $(T_\theta^{\max}(N_\theta^*), N_\theta^*)$ *for both types* θ*, a symmetric separating equilibrium always exists.*
(ii) If the offer to the firm of type h *is* $\left(T_h^{\max}\left(\hat{N}_h\right), \hat{N}_h\right)$ *with* $\hat{N}_h > N_h^*$*, a symmetric separating equilibrium exists only if* p_h *is sufficiently small.*

Proof: (i) $(T_\theta^{\max}(N_\theta^*), N_\theta^*)$ for both types of the firm maximizes the surplus which is completely captured by the firm. A profitable deviation is thus not feasible. (ii) If the offer to the firm of type h implies $\hat{N}_h > N_h^*$, the surplus is lower for the high-productivity firm. In contrast, the best pooling contract implies $\hat{N}_\theta = N_\theta^*$ for both types of the firm (see Lemma 3) and a type-independent lump-sum payment equal to the expected gain from attracting the firm, i.e.

$$\hat{T} = \sum_\theta p_\theta \left(t\left(F_\theta\left(N_\theta^*\right) - wN_\theta^*\right) + w^s N_\theta^*\right). \tag{12}$$

Specifically, with the pooling contract, the firm's surplus is given by $(1-t)\left(F_\theta\left(N_\theta^*\right) - wN_\theta^*\right) + \hat{T}$. The firm of type h prefers the pooling contract if

$$\Pi_h\left(N_h^*\right) - (1-p_h)\left(t\left(\Pi_h\left(N_h^*\right) - \Pi_l\left(N_l^*\right)\right) + w^s\left(N_h^* - N_l^*\right)\right) > \Pi_h\left(\hat{N}_h\right) \tag{13}$$

where $\hat{N}_h > N_h^*$ on the right hand side. With p_H converging to one, the surplus will exceed, at some point, the surplus from the separating contract. Note that the firm of type l will always benefit from a pooling contract since there is cross-subsidization from the firm of type h to the firm of type l. □

The intuition behind the Proposition 2 is as follows. A separating equilibrium with $\hat{N}_h > N_h^*$ leaves the firm of type h with less surplus than under

complete information due to the distortion of production. In contrast, a pooling equilibrium reduces the surplus of the firm of type h due to cross-subsidization. The latter decreases in p_h, while the former is unaffected by p_h. In other words, if the probability that the firm is of type l is too low, separating becomes too expensive for the firm of type h. In this case, there is a pooling contract (but not an equilibrium) in which both types of the firm are better off than in the equilibrium described in Proposition 1 part (ii), and therefore the separating equilibrium does not exist. This is in line with Rothschild and Stiglitz (1976).

To restore an equilibrium in this situation, Dasgupta and Maskin (1986) allow for mixed strategies and prove for the Rothschild-Stiglitz model the existence of an equilibrium in mixed strategies. Their result is directly applicable here. The symmetric equilibrium in mixed strategies has the same properties as the equilibrium in pure strategies. The government realizes a zero net benefit due to the location of the firm and there is overemployment in the high-productivity firm. Other approaches of dealing with the non-existence of equilibrium in a Rothschild-Stiglitz framework can be found in Wilson (1977) and Riley (1979). Wilson (1977) introduces the concept of an anticipatory equilibrium in which governments are allowed to withdraw contracts when they realize that these contracts imply negative net benefits due to the settlement of the firm (given the other government's bid). Applied to the framework here, if the equilibrium in Proposition 1 does not exist, the anticipatory equilibrium pools both types of firms and implies zero net benefits for the governments. If the equilibrium in Proposition 1 exists, it is also a Wilson equilibrium. In contrast, the concept of a reactive equilibrium by Riley (1979) allows the governments to react to unprofitable situations by adding new contracts. With this equilibrium concept the separating equilibrium described in Proposition 1 exists independently of the ex-ante fractions of both types of firms. In general, if a Rothschild-Stiglitz equilibrium does not exist, an equilibrium can only be ensured by extending the governments' scope of action and, therefore, by changing the structure of the game. The characteristics of the equilibrium bidding contracts then depend on the specific equilibrium concept underlying the analysis. In the

following, we will assume that an equilibrium exists.

5 Asymmetric bidding competition

So far we considered perfectly symmetric competition. Now, we allow for asymmetries, i.e. differences between the regions that may affect the properties of the bidding equilibrium.

5.1 High-tax versus low-tax regions

Assume that region 1 levies lower tax rates than region 2; otherwise, the two regions are identical. Under complete information, this would not play a role since the lump-sum payment includes the expected tax revenue from each type of the firm. Then, low-tax regions are no more likely to attract the firm than high-tax regions. With incomplete information, the picture changes. As indicated in the proof of Proposition 1, see (11), high tax rates tighten the ICC_l and make stronger labor demand distortions necessary.

Proposition 3. *Assume that $t_1 < t_2$.*
(i) If $\hat{N}_{h2} = N^*_{h2}$, a symmetric equilibrium as in Proposition 1 occurs; both regions win the firm with equal probability.
(ii) If $\hat{N}_{h2} > N^*_{h2}$, the low-tax region (region 1) wins the bid for the firm of type h and has a larger surplus than under complete information. Its offer to the firm of type h is given by $\left(\hat{T}_{h1}, \hat{N}_{h1}\right)$ with

$$\hat{T}_{h1} = F_h(\hat{N}_{h2}) - w_2\hat{N}_{h2} + w^s\hat{N}_{h2} - (1-t_1)\left(F_h(\hat{N}_{h1}) - w_1\hat{N}_{h1}\right) + \varepsilon \quad (14)$$

and

$$\hat{N}_{h1} \in \left[N^*_{h1}, \hat{N}_{h2}\right).$$

Its offer to the firm of type l is the same as in a symmetric equilibrium (see Proposition 1); both regions win the bid for the firm of type l with equal probability.

Proof: (i) If $\hat{N}_{h2} = N^*_{h2}$, region 2 offers the full surplus to both types of the firm, including tax revenue. Region 1 cannot do better and, thus,

has a fifty percent chance of winning the bid. (ii) If $\hat{N}_{h2} > N^*_{h2}$, i.e. the ICC_l in region 2 is binding, lower tax rates relax the ICC_l in region 1. This allows offering an employment level that is closer to N^*_h but still satisfies the ICC_l. The resulting efficiency gain is captured by the low-tax region. This effect does not occur under complete information, where the region's surplus under symmetry is zero. It does also not occur if the firm is of type l. □

Proposition 3 describes a case in which the region can benefit by more than the total value of the location-specific profits (which in the symmetric case is zero). Compared to the case of complete information, the region gains from the incompleteness of information. The reason is that region 1 competes with a region that offers an employment-distorting contract. In this regard, competition is weaker under incomplete information. With asymmetries in regional tax rates the low-tax region can gain from the fact that information is incomplete only if the firm has high productivity.

5.2 High-wage versus low-wage regions

Assume that the households in region 1 have a lower disutility of work than the households in region 2, but otherwise the regions are identical. As a consequence, the wage rate is lower, as is unemployment. The firm has higher profit in the low-wage region and the profit difference is larger for the high-productivity firm. Therefore, the low-wage region will win the bid. It makes an offer that gives the firm a slightly higher surplus as in region 2. Since lower wages also imply that the desired level of unemployment is higher in region 1, the region can generate a higher surplus than under complete information, if region 2 requires overemployment in the high-productivity firm. Proposition 4 summarizes these results.

Proposition 4. *Assume $w_1 < w_2$. The low wage region wins the bid. The offers made by region 1 are given by $\left(\hat{T}_{\theta 1}, \hat{N}_{\theta 1}\right)$ with*

$$\hat{T}_{\theta 1} = F_\theta(\hat{N}_{\theta 2}) - w_2 \hat{N}_{\theta 2} + w^s \hat{N}_{\theta 2} - (1-t)\left(F_\theta(\hat{N}_{\theta 1}) - w_1 \hat{N}_{\theta 1}\right) + \varepsilon \quad (15)$$

for $\theta = l, h$ and $\hat{N}_{l1} = N^*_{l1}$. If $\hat{N}_{h2} = N^*_{h2}$, then $\hat{N}_{h1} = N^*_{h1}$. If $\hat{N}_{h2} > N^*_{h2}$, then $\hat{N}_{h1} = \max\left\{\hat{N}_{h2}, N^*_{h1}\right\}$ and region 1 has a higher surplus than under complete information.

Proof: Due to lower wages the firm generates higher profit in region 1. This region can therefore offer higher transfers to the firm. The lowest transfer that makes region 1 attracting the firm of type θ with certainty is a transfer that equals the transfer of region 2 adding a small positive amount ε, i.e.

$$\hat{T}_{\theta 1} = F_\theta(\hat{N}_{\theta 2}) - w_2\hat{N}_{\theta 2} + w^s\hat{N}_{\theta 2} - (1-t)\left(F_\theta(\hat{N}_{\theta 1}) - w_1\hat{N}_{\theta 1}\right) + \varepsilon \quad (16)$$

for $\theta = l, h$ and $\hat{N}_{l2} = N^*_{l2}$ and $\hat{N}_{h2} \geq N^*_{h2}$. The government's surplus is then given by $w^s\hat{N}_{\theta 1} + t\left(F_\theta(\hat{N}_{\theta 1}) - w_1\hat{N}_{\theta 1}\right) - \hat{T}_{\theta 1}$ which is maximized at $\hat{N}^*_{\theta 1}$. Now, we check whether the two ICCs hold in region 1. Before we do so, we express the ICC_l in region 2 as

$$\begin{aligned} & F_l(N^*_{l2}) - (w_2 - w^s)N^*_{l2} \quad (17)\\ = \; & \left(F_l(\hat{N}_{h2}) - w_2\hat{N}_{h2}\right)(1-t) + t\left(F_h(\hat{N}_{h2}) - w_2\hat{N}_{h2}\right) + w^s\hat{N}_{h2} + \psi \end{aligned}$$

where $\psi > 0$ is a constant chosen to equate the two sides of the ICC. That is, if $\psi > 0$, the ICC_l in region 2 holds with strict inequality implying $\hat{N}_{h2} = N^*_{h2}$. In contrast, if $\psi = 0$, the ICC_l in region 2 holds with equality implying $\hat{N}_{h2} \geq N^*_{h2}$. Using equation (17), the ICC_l in region 1 holds if

$$F_h(\hat{N}_{h1}) - F_l(\hat{N}_{h1}) \geq F_h(\hat{N}_{h2}) - F_l(\hat{N}_{h2}) - \frac{\psi}{1-t}. \quad (18)$$

Analogously, the ICC_h in region 1 holds if

$$F_h(\hat{N}_{l1}) - F_l(\hat{N}_{l1}) \leq F_h(\hat{N}_{h2}) - F_l\left(\hat{N}_{h2}\right) - \frac{\psi}{1-t}. \quad (19)$$

Several aspects are noteworthy. First, since $\hat{N}_{h1} > \hat{N}_{l1}$, at most one of the above ICCs will be binding. Second, if $\hat{N}_{h2} = N^*_{h2}$, the ICC_l will not be binding at $\hat{N}_{h1} = N^*_{h1}$, i.e. if region 2 has no overemployment, region 1

will not either. Third, if $\hat{N}_{h2} > N^*_{h2}$ (and thus $\psi = 0$), $\hat{N}_{h1}$ needs to be at least as high as $\hat{N}_{h2}$. For $\hat{N}_{h2} > N^*_{h2}$ we have to distinguish two different cases: $N^*_{h1} > \hat{N}_{h2}$ and $N^*_{h1} \leq \hat{N}_{h2}$. If $N^*_{h1} > \hat{N}_{h2}$, the ICC_l in region 1 holds with strict inequality and therefore $\hat{N}_{h1} = N^*_{h1}$. If $N^*_{h1} \leq \hat{N}_{h2}$, region 1 will set $\hat{N}_{h1} = \hat{N}_{h2}$. Due to lower wages $\hat{N}_{h1}$ is closer to N^*_{h1} which implies an efficiency gain which is captured by region 1. It remains to show that the ICC_h holds at $\hat{N}_{l1} = N^*_{l1}$. If region 1 does not distort the employment level of the firm of type h, the ICC_h holds at $\hat{N}_{l1} = N^*_{l1}$. A distortion of the employment level of firm of type l can – if at all – only be rational in the case where $N^*_{h1} \leq \hat{N}_{h2}$. If region 1 distorts the employment level of the firm of type h also region 2 does so and therefore $\psi = 0$ in equation (17). The ICC_h of region 1 given as stated in equation (19) then reads

$$F_h(\hat{N}_{l1}) - F_l(\hat{N}_{l1}) \leq F_h(\hat{N}_{h2}) - F_l\left(\hat{N}_{h2}\right). \tag{20}$$

This equation holds if $\hat{N}_{l1} < \hat{N}_{h2}$. Since $N^*_{h1} \leq \hat{N}_{h2}$ holds in the considered case and $N^*_{l1} < N^*_{h1}$ always holds, it follows $N^*_{l1} < \hat{N}_{h2}$. This proves that the ICC_h of region 1 holds at $\hat{N}_{l1} = N^*_{l1}$. The employment level of the low-productivity firm is therefore never distorted. □

Proposition 4 implies that, in equilibrium, the low-wage region attracts both types of the firm.[16] It describes another case in which the winning region is able to reduce the employment distortion due to incomplete information and capture the resulting efficiency gain. The surplus is, thus, higher than with complete information. In contrast to the case where asymmetries are given in the regional tax rates, with asymmetries in wage rates the low-wage region can gain from the fact that information is incomplete independent of the productivity of the firm.

[16] This results may be seen in the light of the findings in Haufler and Mittermaier (2011) who show that countries with more unionized labor markets are more likely to win the bidding competition (although in a different model than ours).

5.3 High-benefit versus low-benefit regions

Assume that region 1 pays lower unemployment transfers than region 2 that is $w_1^s < w_2^s$; otherwise, both regions are identical. Since an increase in unemployment benefits increases the wage rate, the high-benefit region is also the high-wage region. More precisely, the labor market equlilibrium (3) requires

$$v(w_i, 1) = v(w_i^s, 0), \quad i = 1, 2 \tag{21}$$

where the concavity of the utility function implies $w_1 - w_1^s < w_2 - w_2^s$. Since the desired employment level $N_{\theta i}^*$ for the firm of type θ is determined by $\partial F_\theta \left(N_{\theta i}\right) / \partial N_{\theta i} = w_i - w_i^s$, it is $N_{\theta 1}^* > N_{\theta 2}^*$. We can therefore state Proposition 5.

Proposition 5. *Assume $w_1^s < w_2^s$. The region that pays the lower unemployment benefits wins the bid. If $\hat{N}_{h2} > N_{h2}^*$, region 1 has a higher surplus than under complete information.*

Proof: Since region 1 is not only the region with lower unemployment benefits but also the low-wage region and the region that requires the higher desired level of employment $N_{\theta 1}^* > N_{\theta 2}^*$, the argumentation given in the proof of Proposition 4 also proves this proposition. □

6 Discussion and conclusion

This paper focusses on the role of incomplete information for the bidding behavior of regions. Incomplete information may explain some of the typical features of real-world bidding contests like (contractually fixed) firm-specific performance targets on investment and employment. These targets are likely to imply an inefficiently high level of employment. Our model may thus explain why sometimes (e.g. in the case of Nokia, see the introduction) a firm may have an ex-post incentive to employ not as many workers as it originally agreed upon. Another implication is that, in some of the above

analyzed cases, incomplete information actually benefits the regional governments. The reason is that, if the losing region offers a contract with inefficiently high employment, the winning region may, under asymmetry, offer a less distortionary employment target and capture the efficiency gain. This highlights the role of information for the evaluation of interjurisdictional competition.

Our results hinge on the assumption that the regions cannot commit to future tax rebates. Otherwise, full tax rebates and the desired employment levels would be the equilibrium offer in the symmetric situation. Although this assumption may be debatable, we believe that our results are robust as long as there is some benefit of attracting the firm which cannot be contracted upon. In a previous version of this paper, we consider a somewhat more complicated model where tax rebates can be committed upon but spillovers cannot (see Becker and Schneider 2014). The results are similar to the ones derived here. An alternative argument for upfront payments by the region is provided by Bond and Samuelson (1986) who argue that governments may have better information on their regions profitability. Then, simply offering a contract with a tax rebate and an employment level may not be enough to convince the firm that the location is of high quality. An upfront payment may act as a signal for the (expected) profits that the firm can earn in the region under consideration.[17]

Employment distortions only arise, of course, if regions are allowed to offer this kind of contract. If regions can only make offers in terms of lump-sum payments, a separating contract would not be feasible. Employment would not be distorted upwards, but cannot take account of unemployment benefit savings either. It is an open question, therefore, if banning employment targets have a positive impact on overall surplus or not. However, since a pooling equilibrium implies cross-subsidization from the low-productivitiy to the high-productivity firm, it is almost sure that the high-productivity firm would lose.

[17] A promising route for future research would be to allow for two-sided incomplete information (as pioneered in King and Welling 1992). That is, the firm has some private information and the governments as well.

Finally, the question may arise how the results would change if more than two regions compete for the firm. In the cases where the firm receives the full surplus, the properties of the equilibrium would not change since a third competitor cannot offer a better bid (as long as we abstract from asymmetries). However, in the cases in which asymmetries imply a non-zero gain for the regional governments, market entry would erode these gains if the entrants are more similar to the winning region.

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